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PTO/SB/05 (4/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	SIM013
First Inventor or Application Identifier	Tue Nguyen
Title	High Pressure Chemical Vapor Trapping System
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: **Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231**

1. [X] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [X] Specification [*Total Pages* 13] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 3]
4. Oath or Declaration [*Total Pages* 2]
   a. [X] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 16 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b)

NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

5. [ ] Microfiche Computer Program *(Appendix)*
6. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

7. [X] Assignment Papers (cover sheet & document(s))
8. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [X] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
11. [ ] Preliminary Amendment
12. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
13. [X] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
14. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
15. [ ] Other: ....

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[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ________/__________

Prior application information: Examiner ________ Group / Art Unit: ________

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

17. CORRESPONDENCE ADDRESS

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Signature		*Date*	6/7/00

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Docket Number (Optional) SIM013

Applicant, Patentee, or Identifier: Tue Nguyen
Application or Patent No.: ______
Filed or Issued: ______
Title: High Pressure Chemical Vapor Trapping System

I hereby state that I am
☐ the owner of the small business concern identified below:
☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF SMALL BUSINESS CONCERN Simplus System Corporation

ADDRESS OF SMALL BUSINESS CONCERN 40737 Encyclopedia Circle, Fremont, CA 94538

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☒ the application identified above.
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☒ no such person, concern, or organization exists.
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NAME OF PERSON SIGNING Tue Nguyen

TITLE OF PERSON IF OTHER THAN OWNER President

ADDRESS OF PERSON SIGNING 496 Olive Ave., Fremont, CA 94539

SIGNATURE ______ DATE 6/7/2000

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High pressure chemical vapor trapping system

Invented by

Tue Nguyen

High pressure chemical vapor trapping system

Field of the invention

The present invention relates generally to apparatus for processing of a semiconductor wafer, and more particularly to a high pressure trapping system to collect chemical vapor by-products in successive stages through chemical reactions conducted at progressively colder temperatures.

Background of the invention

Semiconductor processes use vapor precursors for processing of thin films on an integrated circuit (IC) substrate. The majority of these vapor precursors, together with their by-products, are pumping out and exhausted to a waste stream.

It is very expensive to collect and dispose of the precursor exhaust products. Further, these non-reactive precursors and these byproducts can be hazardous and harmful to the environment. The IC industry is forced to conform to ever more stringent regulations concerning the storage and disposal of these wastes.

It is very inconvenient to collect waste as a gas because it is difficult to transport and bulky to store. It is more convenient if the waste can be converted, at least partially into a solid or liquid waste. It is well known to use cold traps to completely condense some chemical vapors. It is also well known to use cold traps to condense elements of a precursor to at least simplify the waste collection process.

In a chemical vapor deposition (CVD) process, high temperature process is often used. Because of the low efficiency of the CVD process, a hot trap is recommended for completing the CVD reaction, leaving only the by-products to

the exhaust stream. An example is copper CVD process. Copper CVD process uses copper-hfac-tmvs precursor to deposit copper on a hot surface (~200°C) following the reaction:

$$2\ \text{Cu-hfac-tmvs} \rightarrow \text{Cu} + \text{Cu(hfac)}_2 + 2\ \text{tmvs} \quad (\text{at} > \sim 100°\text{C})$$

The reaction occurs at temperature higher than ~100°C. The efficiency of this reaction is roughly 10-20%, thus 80-90% of the precursor leaves the process chamber un-reacted. A cold trap would then collect the precursor Cu-hfac-tmvs, and the by-products $Cu(hfac)_2$ and tmvs. Using a hot trap before the cold trap, most of the precursor would further reacts, leaving only the by-products in the waste stream.

Fig. 1 shows a prior art apparatus for such a recovery and abatement of CVD copper process. Precursor exhaust leaves the process chamber 10, encounters the hot trap 20 to further the reaction. The vacuum pump 30 then pumps away the precursor exhaust. The exhaust then encounters the cold trap 40 to trap all precursor by-products which then drop into the drain 45. The vacuum pump is located after the hot trap to avoid deposition inside the pump, thus prolong the pump life.

The major disadvantage of this prior art is the potential contamination of the process chamber due to the hot trap. With the hot trap raising the efficiency from 10-20% to 100%, the amount of by-products $Cu(hfac)_2$ and tmvs will increase 3-5 times, increasing the potential contaminants products, in this case $Cu(hfac)_2$ and tmvs, 3-5 times. Also the efficiency of the hot trap is low because of the low pressure inside the hot trap, and the hot and cold traps would be two separate units. However, the prior art recommends using this configuration to avoid damage to the vacuum pump.

It would be advantageous if hot and cold traps could be combined in a single system to collect different types of wastes from an exhausted chemical vapor.

It would be advantageous if a multi-stage trapping system could be provided that operated at a high pressure so that the chemical reactions in the traps are efficient.

Summary of the invention

Accordingly, a high pressure chemical vapor trapping system to separate and collect elements of a chemical vapor exhaust is provided. The system comprises a hot trap and a cold trap connected to each other as a single unit. The exhaust pump is upstream of the trapping system, providing a high pressure in the hot trap. While prior art proposes positioning the hot trap upstream of the exhaust pump to avoid damage to the pump, we found no significant damage to the exhaust pump by having the pump connected directly to the process chamber. The reason is that most processes require high temperature for deposition, thus there is minimum deposition at the pump, since the pump temperature is much lower than most process temperature. With wet pump, the only side effect is the faster degradation of the pump oil, thus needing a more frequent oil changing schedule. However, in the case of the dry pump, since it uses no oil, there is no effect on the pump. Since a dry pump typical runs at less than ~70°C temperature, and a wet pump runs at room temperature while the deposition process uses much high temperature, typical 200°C for MOCVD copper deposition, and 400-500°C for PECVD deposition, and 1000-1100°C for rapid thermal deposition, the prior art concern that there is significant deposition at the pump, leading to the degradation of the pump, is proven by this invention to be not correct.

The present invention system comprises a hot trap having an input port, a gas output port, a waste collection surface, and a heater. The heater heats the hot trap to a temperature in the range from 100 to 500 degrees Celsius. The hot trap accepts chemical vapor such as the above-described copper precursors and provides non-gaseous wastes at the waste collection surface, and gaseous exhaust at the gas output port at a pressure substantially the same as the input pressure.

The system also comprises a cold trap having an input port operatively connected to the gas output port of the hot trap, a gas output port, and a waste collection surface. The cold trap cools the chamber to a temperature in the range from 25 degrees to minus 200 degrees Celsius. The cold trap provides non-gaseous wastes at the waste collection surface, and gaseous exhaust at the gas output port at a pressure substantially the same as the input pressure. In this manner, vapor byproducts are collected in two stages.

The invention further provides that an exhaust pump, operatively connected to hot trap input port, provides gaseous exhaust to the hot trap. In this manner, a high pressure is created at the hot trap gas input port

The invention further provides a second cold trap. The second cold trap, set to be colder that the first cold trap, can trap the exhaust gas that has a lower temperature. In this manner, vapor byproducts are collected in three stages. In the example of Cu-hfac-tmvs, the first cold trap is set at temperature below room temperature to trap the by-product $Cu(hfac)_2$. The second cold trap is set at lower temperature (~-40°) to trap the other by-product tmvs.

In some aspects of the invention, the chemical vapor exhaust is a MOCVD precursor such as Cu(hfac) combined with a ligand (Cu(hfac)L). Then, the first chamber includes a plurality of metal plates, or other heated structures extending into the hot trap. These metal plates are of the same metal as in the MOCVD precursor and act as metal collection surfaces. That is, the collection surface acts as the heater in the hot trap. As the precursor vapor is heated, metal from the precursor is deposited on the metal plates as the heat completes the chemical reaction. The metal collection surface/heaters are reclaimed from recycling when a predetermined amount of solid metal waste is collected on the collection surfaces.

In some aspects of the invention, the both the hot and cold chambers are easily removable for efficient recycling of the collected waste materials. A first exhaust line extends to the exhaust input port of the hot trap. The first line including at least one valve to block the passage of gas from the deposition chamber. Likewise, a second exhaust line extends from the hot trap gaseous exhaust port, and also includes at least one valve to block the escape of gas from the second line.

The hot trap includes a first valve at the exhaust input port and a second valve at the gaseous exhaust port. The hot trap is removable from the first and second lines for waste removal, when full. In this manner, the first and second valves in said hot trap prevent exhaust from escaping from the trap, when the trap is disconnected. The valves in the first and second lines prevent the escape of exhaust from the system when the hot trap is removed. In the same manner, valves are used in the gas lines going to and from the cold trap, and also used in the input and output gas ports. Then, the cold trap is also easily removable without allowing the escape of vapors from the system.

Sometimes the hot trap collection surfaces are biased with a voltage, whereby charged metal from the MOCVD precursor is attracted and deposited on said collection surface. In other aspects of the invention, the hot trap includes a second input port to accept a catalyst selected from the group consisting of water, alcohol, and ammonia, whereby the catalyst furthers the chemical reaction in the first chamber.

Brief description of the drawings

Fig. 1 shows a prior art trapping system.

Fig. 2 shows the present invention of the high pressure chemical vapor trapping system.

Fig. 3 shows another aspect of the present invention of the high pressure chemical vapor trapping system.

Detail description of the preferred embodiment

Fig. 2 shows the present invention of the high pressure chemical vapor trapping system. The exhaust from the processing chamber 110 is pumped away by the vacuum pump 130. The pressure in the process chamber foreline 115 is normally low, in the range of torr or millitorr pressure. After the vacuum pump, the pressure is almost atmospheric at the vacuum pump exhaust 135. The hot trap 120 converts un-reacted precursors to the precursor by-products, and the cold trap 140 converts the gas phase by-products to non-gaseous phase by-products for easily transport and storage. The present invention connects to the downstream of the vacuum pump to take advantage of the high pressure at the

pump exhaust. By not disturbing the chamber configuration, there is no potential contamination of the process.

The present invention discloses the use of the hot trap after the vacuum pump without any observable degradation to the vacuum pump, and without any contamination to the process chamber.

Fig. 3 shows another aspect of the present invention of the high pressure chemical vapor trapping system. A bias voltage 127 is applied to the hot trap to accelerate the deposition process. A catalyst inlet 125 is supplied to the hot trap also to accelerate the deposition process, thus improve the efficiency of the hot trap.

What is claimed is:

1. A high pressure chemical vapor trapping system to separate and collect elements of a chemical vapor exhaust comprising:

a) a first processing chamber having a first chamber input port, a first chamber gas output port, a first chamber waste collection surface, and a chamber heater to heat the first processing chamber to a first temperature, the first processing chamber accepting chemical vapor exhaust at the first chamber input port at a trapping pressure to further a chemical reaction, and providing non-gaseous wastes at the first chamber waste collection surface, and providing gaseous exhaust at the first chamber gas output port; and

b) a second processing chamber having a second chamber input port operatively connected to the first chamber gas output port, a second chamber gas output port, a second chamber waste collection surface, and a second chamber cooler to cool the second processing chamber to a second temperature, less than the first temperature, the second processing chamber accepting chemical vapor exhaust at the second chamber input port to further a chemical reaction, and providing non-gaseous wastes at the second chamber waste collection surface, and gaseous exhaust at the second chamber gas output port, whereby vapor byproducts are collected in two stages.

2. A high pressure trapping system as in claim 1 further comprising:

c) an exhaust pump having an output operatively connected to the first processing chamber input port to provide gaseous input to the first

processing chamber, whereby a high pressure is created at the first processing chamber gas input port.

3. A high pressure trapping system as in claim 1 further comprising:
   e) a third processing chamber having a third chamber input port operatively connected to the second chamber gas output port, a third chamber gas output port, a third chamber waste collection surface, and a third chamber cooler to cool the third processing chamber to a third temperature, less than the second temperature, the third processing chamber accepting chemical vapor exhaust at the third chamber input port to further a chemical reaction, and providing non-gaseous wastes at the third chamber waste collection surface, and providing gaseous exhaust at the third chamber gas output port, whereby vapor byproducts are collected in three stages.

4. A high pressure trapping system as in claim 1 in which the first processing chamber first temperature is in the range from 100 to 500 degrees Celsius.

5. A high pressure trapping system as in claim 1 in which the second processing chamber second temperature is in the range from 25 degrees to minus 200 degrees Celsius.

6. A high pressure trapping system as in claim 1 wherein the chemical vapor exhaust is a MOCVD precursor exhaust, in which the first processing chamber includes a plurality of collection surfaces extending into the first processing chamber, the collection surfaces being heated to the first temperature, and in which the metal collection surfaces are reclaimed when a

predetermined amount of solid metal waste is collected on the collection surfaces.

7. A high pressure trapping system as in claim 1 further comprising a first valve at the first processing chamber input port, and a second valve at the first processing chamber output port, whereby the first and second valves in the first processing chamber prevent exhaust from escaping from the first processing chamber when the first processing chamber is disconnected.

8. A high pressure trapping system as in claim 1 further comprising a third valve at the second processing chamber input port, and a fourth valve at the second processing chamber output port, whereby the third and fourth valves in the second processing chamber prevent exhaust from escaping from the second processing chamber when the second processing chamber is disconnected.

9. A high pressure trapping system as in claim 3 further comprising a fifth valve at the third processing chamber input port, and a sixth valve at the third processing chamber output port, whereby the fifth and sixth valves in the third processing chamber prevent exhaust from escaping from the third processing chamber when the third processing chamber is disconnected.

10. A high pressure trapping system as in claim 1 wherein the chemical vapor exhaust is a MOCVD precursor, in which said first processing chamber collection surface is biased with a voltage, whereby charged metal from the MOCVD precursor is attracted and deposited on the collection surface.

11. A high pressure trapping system as in claim 10 wherein the bias voltage is in the range from -10 to -100 volts DC, whereby positively charged metal from the MOCVD precursor is attracted and deposited on the collection surface.

12. A high pressure trapping system as in claim 10 wherein the bias voltage is in the range from 10 to 100 volts DC, whereby negatively charged metal from the MOCVD precursor is attracted and deposited on the collection surface.

13. A low pressure trapping system as in claim 1 in which the first processing chamber includes a second input port to accept a catalyst to furthers the chemical reaction in the first chamber.

14. A low pressure trapping system as in claim 13 in which the catalyst is selected from the group consisting of oxygen, water, alcohol, and ammonia.

Abstract

A high pressure trapping system is provided to collect chemical vapor by-products in successive stages through chemical reactions conducted at progressively colder temperatures. A hot trap receives chemical vapor exhaust and collects a first waste, typically a solid, as a result of the high temperature completing a chemical reaction in the vapor. Surviving gaseous by-products continue to the next process. The following chamber is colder, and collects waste as a solid or a liquid as a result of a chemical process dependent on the cold temperature. Sometimes a third chamber is used for even a colder chemical reaction to collect waste products. As a solid, these waste products are easier to collect, remove, and even reuse.

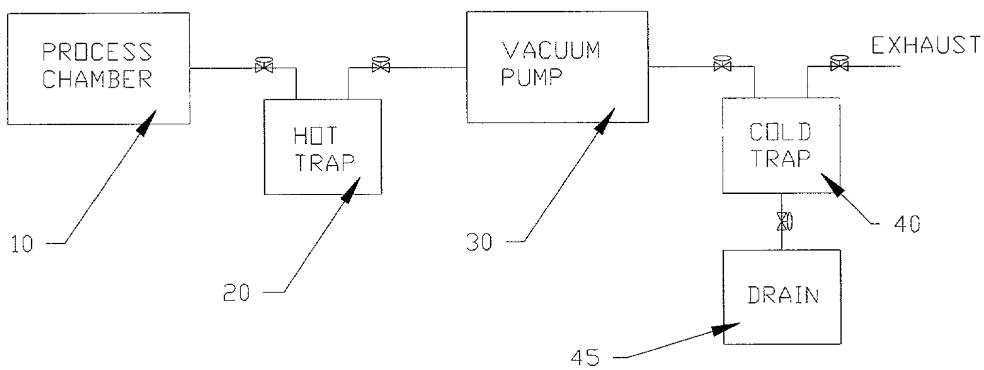

Fig. 1 (Prior Art)

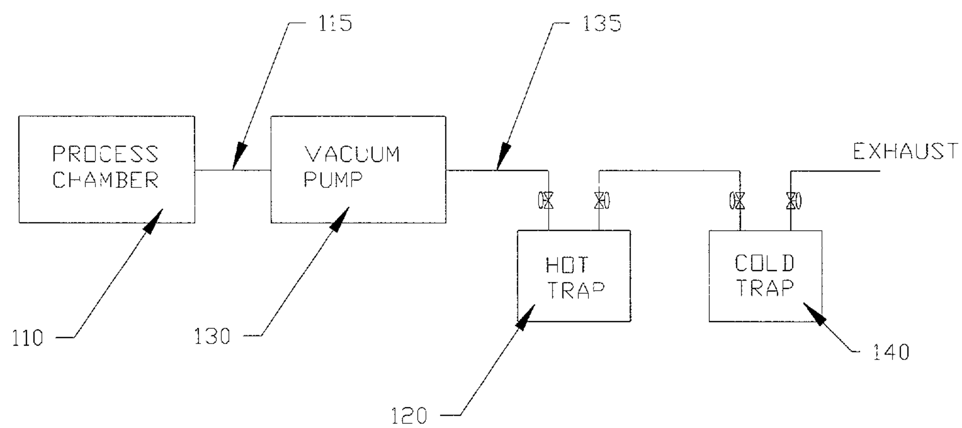
115
135
PROCESS CHAMBER
VACUUM PUMP
EXHAUST
HOT TRAP
COLD TRAP
110
130
140
120

Fig 2

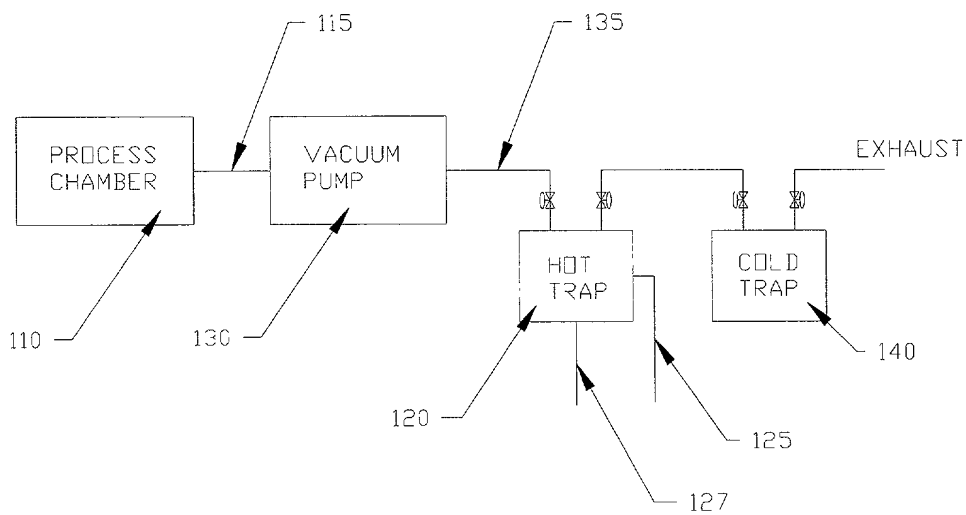
115
135
PROCESS CHAMBER
VACUUM PUMP
EXHAUST
HOT TRAP
COLD TRAP
110
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Fig 3

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

[X] Declaration Submitted with Initial Filing **OR** [ ] Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	SIM013
First Named Inventor	Tue Nguyen
COMPLETE IF KNOWN	
Application Number	/
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

High Pressure Chemical Vapor Trapping System

(Title of the Invention)

the specification of which

[X] is attached hereto

OR

[ ] was filed on (MM/DD/YYYY) [ ] as United States Application Number or PCT International Application Number [ ] and was amended on (MM/DD/YYYY) [ ] (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]
			[ ]	[ ]	[ ]

[ ] Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)	
		[ ] Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*

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OR
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Name	Registration Number	Name	Registration Number

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Direct all correspondence to: ☐ Customer Number or Bar Code Label [ ] *OR* ☒ Correspondence address below

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Address					
City	Fremont	State	CA	ZIP	94539
Country	USA	Telephone	(510) 656-4420	Fax	(510) 656-4420

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Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

Given Name (first and middle [if any])	Family Name or Surname
Tue	Nguyen

Inventor's Signature	[signature]					Date	6/7/00
Residence: City	Fremont	State	CA	Country	USA	Citizenship	USA
Post Office Address							
Post Office Address							
City		State		ZIP		Country	

☒ Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto